Appendix E

Volume Calculations for Dredging Alternatives 2 and 3

Volume Calculations

Sediment volumes were calculated for the five dredging scenarios (Alternatives 2A through 2C and 3A and 3b) described in Section 6 of the Concept Design Report (Barr, 2004). The dredging scenarios are based on environmental, navigational, recreational, and economic concerns. Elevated concentrations of PCBs and PAHs were generally observed at similar sediment elevations. Because of this observation and the similar chemical and physical properties of PCBs and PAHs, dredging depths were based on PCB concentrations in the sediments. It is assumed that removing areas with elevated PCB concentrations will also address areas with elevated PAH concentrations.

The project area (Figure 1) was divided into three sections (Figure 2), which groups the river into areas with similar contaminant extent and concentrations. These sections were used to describe the dredging and/or capping scenarios described below. The top of sediment contours (Figure 3), dredging volumes, and surface areas for partial sediment capping were calculated using Surfer® (Golden Software, Inc., Version 8), a contouring and surface mapping program. The top of sediment contours were determined using bathymetry data collected by the USACE on August 27, 2002. The bathymetry data and the Kriging algorithm, which is a geostatistical interpolation method that is part of the Surfer® program, were used to interpolate the top of sediment contours shown in Figure 3.

Once the top of sediment contours were created, dredging volumes were calculated in Surfer® by subtracting the proposed dredging elevation or contour for each alternative from the top of sediment contours and then integrating the difference to determine a dredging volume for each alternative. This was done by section for each alternative. Listed below is a table that lists the dredging volumes by section for each dredging alternative. A more detailed description of the Surfer® program and calculations are provided at the end of this Appendix.

Source: USACE & WDNR. April 7, 2004. Kinnickinnic River, Wisconsin - Milwaukee Estuary of Concern - Deepening/Remediation Concept Design Documentation Report. Appendix E.

Dredging Alternative	Section 1 Sediment Volume (ft^3)	Section 2 Sediment Volume (ft^3)	Section 3 Sediment Volume (ft^3)	Total Sediment Volume (ft^3)	Total Sediment Volume (yd^3)
2A	1,134,950	1,855,386	2,187,592	5,177,928	192,000
2B	628,167	1,024,935	830,679	2,483,781	92,000
2C	745,117	1,184,418	1,027,343	2,951,878	110,000
3A	944,976	1,765,251	1,874,496	4,584,723	170,000
3B	722,771	1,419,097	1,466,658	3,608,526	134,000

It should be noted that the total sediment volumes were rounded up to the nearest 1,000 cubic yards.

Capping Area and Volume Calculation

The volume of sediment required for capping the project areas were also calculated in Surfer® by calculating the positive planar area of the project area and multiplying that by the thickness of the cap. The capping areas were the same for both of the capping dredging alternatives (2B and 2C). Listed below are the capping areas by section and the total volume of capping material required for a 3 foot cap across the entire project area.

Dredging Alternatives	Section 1 Capping Area (ft^2)	Section 2 Capping Area (ft^2)	Section 3 Capping Area (ft^2)	Total Capping Area (ft^2)	Total Capping Volume for a 3-ft Cap (yd^3)
2B & 2C	722,771	1,419,097	1,466,658	3,608,526	134,000

It should be noted that the total the total capping volumes were rounded up to the nearest 1,000 cubic yards.

Source: USACE & WDNR. April 7, 2004. Kinnickinnic River, Wisconsin - Milwaukee Estuary of Concern - Deepening/Remediation Concept Design Documentation Report. Appendix E.

Surfer® Technical Details

Technical details regarding how sediment contours were interpolated using the Kriging algorithm and how volumes were calculated in Surfer® are described below:

Contour Interpolation Using the Kriging Algorithm (from Surfer® help tutorial)

Kriging was used to determine the top of sediment contours for this project using bathymetry data collected by the USACE. In short, Kriging is a geostatistical gridding method that has proven useful and popular in many fields. This method produces visually appealing maps from irregularly spaced data. Kriging attempts to express trends suggested in your data, so that, for example, high points might be connected along a ridge rather than isolated by bull's-eye type contours.

Kriging is a very flexible gridding method. You can accept the Kriging defaults to produce an accurate grid of your data, or Kriging can be custom-fit to a data set by specifying the appropriate variogram model. Within Surfer®, Kriging can be either an exact or a smoothing interpolator depending on the user-specified parameters. It incorporates anisotropy and underlying trends in an efficient and natural manner. For this project, sediment contours were interpolated using the default kriging variogram and exact interpolation.

Calculations (from Surfer® help tutorial)

Sediment volumes were calculated in Surfer® using the top of sediment contours interpolated from the bathymetry data collected by the USACE and the proposed dredging elevations. In Surfer®, volume calculations are performed on solids defined by an upper and lower surface. The upper and lower surfaces are defined by a grid file or a plane of constant Z level. For this project, the upper surface was the top of sediment contours and the lower surface was the proposed dredging elevation.

Volume calculations were generated for each grid cell. For this project, grid cells were 3 feet by 3 feet. In areas where the surface is tilted at the top or bottom of a grid cell, Surfer® approximates the volume of the prism at the top or bottom of the grid cell column. Volume calculations become more accurate as the density of the grid is increased because the relative size of the prisms is reduced compared to the size of the associated column.

Source: USACE & WDNR. April 7, 2004. Kinnickinnic River, Wisconsin - Milwaukee Estuary of Concern - Deepening/Remediation Concept Design Documentation Report. Appendix E.

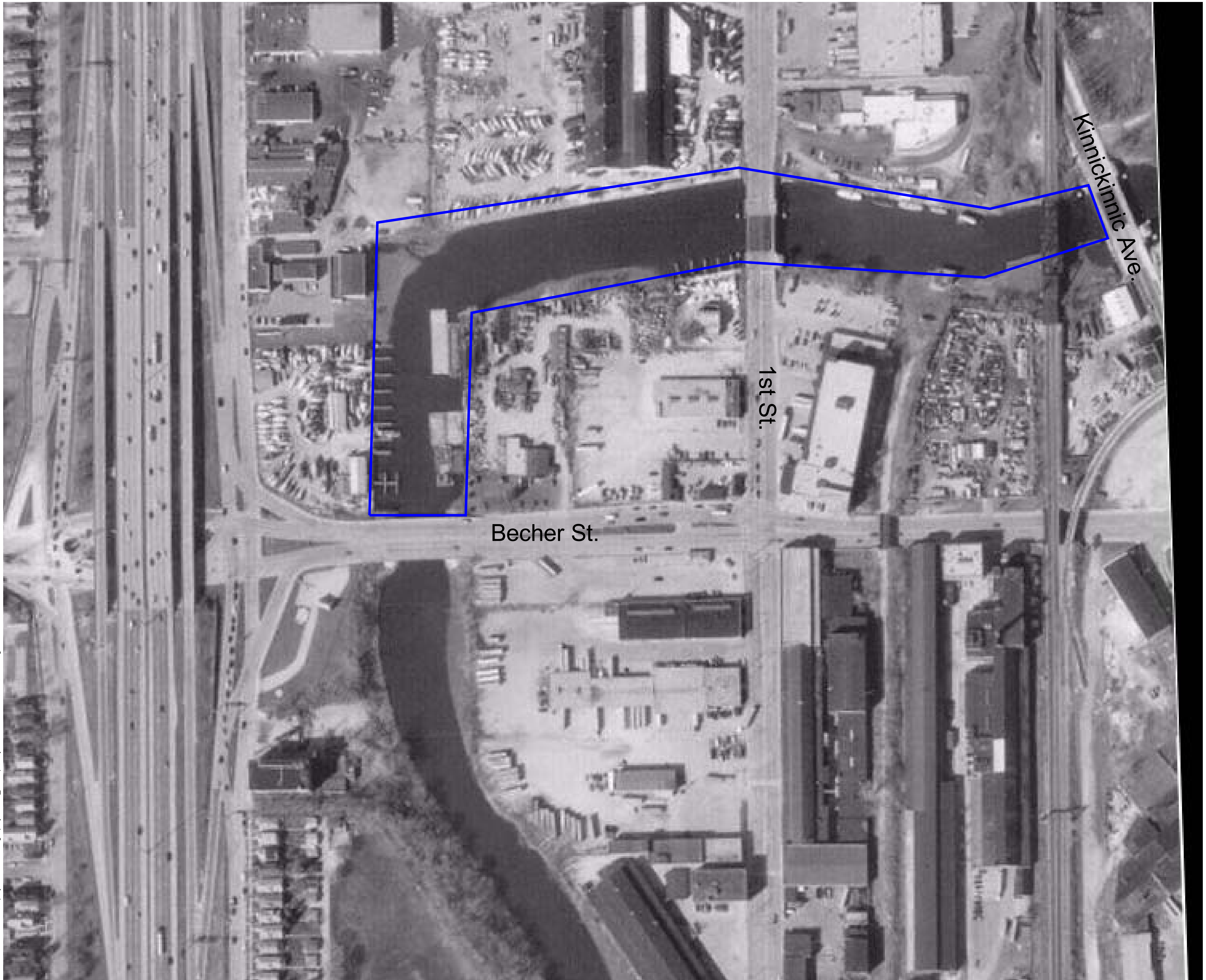
References

Barr Engineering. 2004. *Concept Design Documentation Report: Kinnickinnic River, Wisconsin – Milwaukee Estuary of Concern Sediment Removal.*

Golden Software, Inc. *Surfer User's Guide: Contouring and 3D Mapping for Scientists and Engineers.* Golden Software Company, 1999.

Isaaks, E.H. and R.M. Srivastava. *An Introduction to Applied Geostatistics.* Oxford University Press, 1989.

Source: USACE & WDNR. April 7, 2004. Kinnickinnic River, Wisconsin - Milwaukee Estuary of Concern - Deepening/Remediation Concept Design Documentation Report. Appendix E.



Remediation Area

N

200 0 200 Feet

Figure 1
Site Location
Kinnickinnic River
Sediment Removal Concept Plan
Milwaukee, WI

Prepared for:
USACE
DETROIT DISTRICT

Prepared by:
BARR
MINNEAPOLIS, MINNESOTA
HIBBING, MINNESOTA
DULUTH, MINNESOTA
ANN ARBOR, MICHIGAN
JEFFERSON CITY, MISSOURI

Barr: Arcview 3.1,PIV02, i:\projects\49\41\016\gis\project\kinn_river.apr, Layout: Site Location, ksw, Thu Aug 07 14:03:17 2003

2002 Boring Locations

Section Locations

- Section 1
- Section 2
- Section 3

Figure 2
Section and Sampling Locations
Kinnickinnic River
Sediment Removal Concept Plan
Milwaukee, WI

Prepared for:
USACE
DETROIT DISTRICT

Prepared by:
BARR
MINNEAPOLIS, MINNESOTA
HIBBING, MINNESOTA
DULUTH, MINNESOTA
ANN ARBOR, MICHIGAN
JEFFERSON CITY, MISSOURI

Barr: Arcview 3.1,PIV02, i:\projects\49\41\016\gis\project\kinn_river.apr, Layout: Section and Sampling Locations - logos, ksw, Thu Aug 07 14:07:45 2003

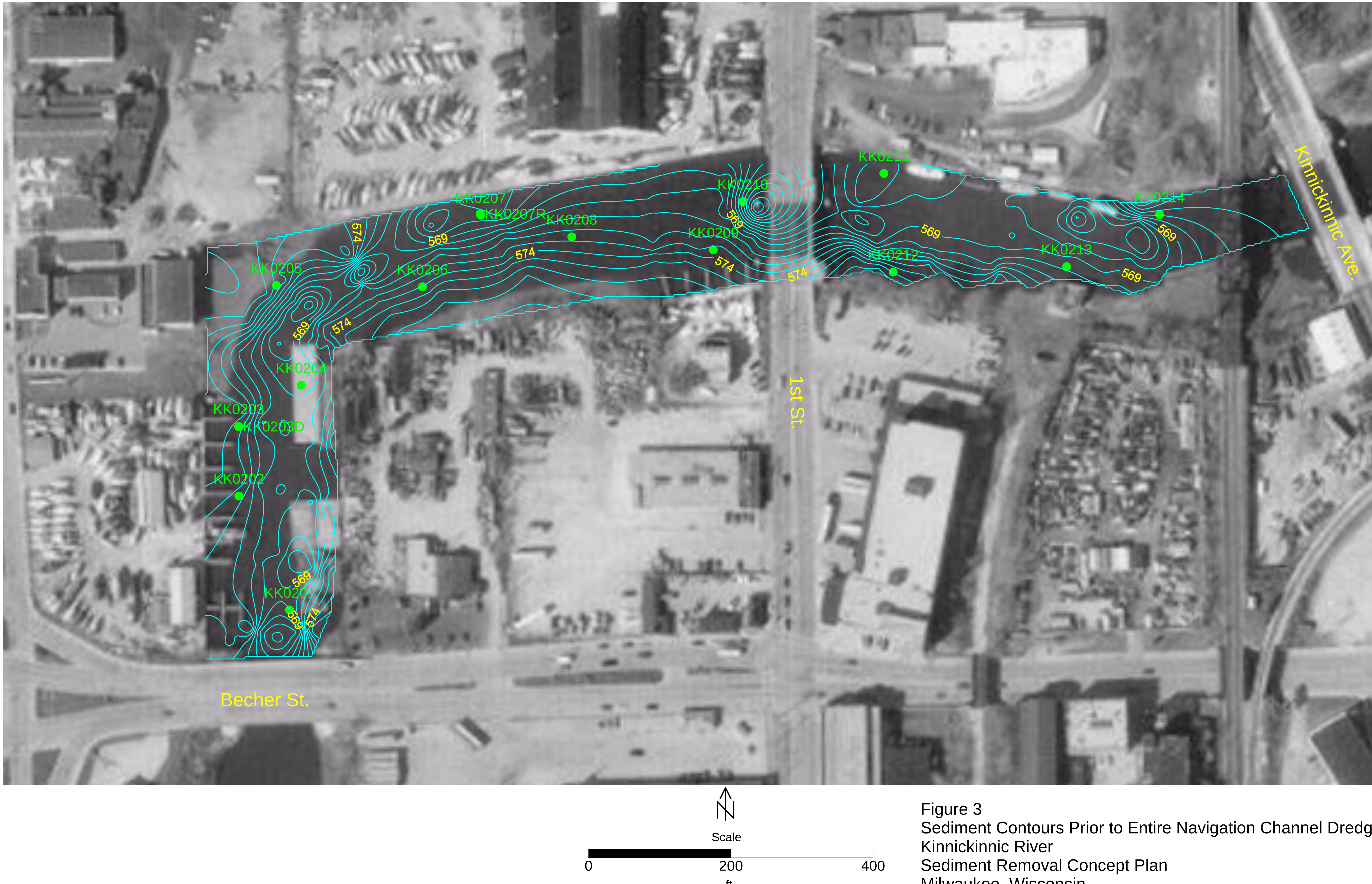


Figure 3
Sediment Contours Prior to Entire Navigation Channel Dredging
Kinnickinnic River
Sediment Removal Concept Plan
Milwaukee, Wisconsin